I SEMESTER

21LN01 APPLIED NUMERICAL METHODS

Vide Automobile Engineering 21AE01

21LN02 FUNDAMENTALS OF NANOSCIENCE AND TECHNOLOGY

3 1 0 4

NANO EVOLUTION: Scientific evolution - Feynman's quantum electrodynamics – Taniguchi's nanotechnology – Drexler's engines of creation – Definition of a nanosystem – Dimensionality and size dependent phenomena - Nanostructures – Naturally occurring nanomaterials - Nanoscale properties - Magnetic Moment in clusters/Nanoparticles – Coercivity – Thermal activation and superparamagnetic effects, Excitonic binding and recombination Energies, Capacitance in a nanoparticle, Optical properties - Surface Plasmon Resonance, Nanotechnology Initiatives – challenges and future prospects of nanoscience. (12+4)

QUANTUM CONCEPTS: Inadequacies of Classical Mechanics – Duality nature of electromagnetic radiation – De Broglie hypothesis for matter waves – Heisenberg's uncertainty principle – Schrödinger's wave equation - Energy levels of a particle, Density of states (DOS) - DOS of 3D, 2D, 1D and 0D materials - Quantum confinement - Penetration of a barrier, Tunnel effect - Ballistic transport - Coulomb blockade. (11+4)

INTERMOLECULAR AND INTRAMOLECULAR FORCES: Atomic structure - bonds, chemical bonds, ionic interactions, covalent bonds, metal bonds, hydrogen bonds – covalent and coulomb interactions – electrostatic stabilization - surface charge density - electric potential at the proximity of solid surface - van der Waals forces - dipole-dipole interactions – repulsive forces - hydrophobic and hydrophilic interactions, super-hydrophobicity. (11+4)

TRANSPORT IN THE NANOSCALE: Size effect on electronic properties – phonons in nanostructures - size effect on electron – phonon coupling, evolution of band structures and Fermi surface - fraction of surface atoms – surface energy and surface stress, size-induced metal-insulator-transition (SIMIT)- electron transport and kinetics in zero, one and two dimensional nanostructures - nanocrystalline materials, effect of grain size and grain boundaries. (11+3)

Total L: 45 + T: 15 = 60

TUTORIAL COMPONENTS:

- Size dependendent optical properties of nanoparticles
- Origin and principles of quantum mechanics
- Surface morphology and grain size measurement
- Compression and hardness tests

REFERENCES:

1. Pradeep T, Nano: The Essentials Understanding Nanoscience and Nanotechnology, Mc-Graw Hill, New Delhi, 2007.
2. Masaru Kuno, Introductory Nanoscience: Physical and Chemical Concepts, Garland Science, New York, 2012.
3. Aruldhas G, Quantum Mechanics, PHI Learning Pvt. Ltd., New Delhi. 2013.
4. Gabor L Hornyak, Harry F Tibbals, Joydeep Dutta, John J Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, Boca Raton, 2009.
5. Mathews P M, Venkatesan K, A Text book of Quantum Mechanics, Tata McGraw Hill, New Delhi, 2010.
6. Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, Concepts of Modern Physics, McGraw Hill, New Delhi, 2017.

21LN03 SYNTHESIS OF NANOMATERIALS

3 0 0 3

CONCEPTS IN NANOMATERIAL SYNTHESIS: Bottom-Up and Top-Down Approaches - Surface Energy; Electrostatic Stabilization-Surface charge density-Electric potential at the proximity of solid surface-Van der Waals attraction potential - DLVO theory; Steric stabilization-Solvent and polymer-Interactions between polymer layers-Mixed steric and electric interactions; Homogeneous and heterogeneous nucleation - Growth controlled by diffusion and surface process. (11)

CHEMICAL APPROACHES: Synthesis of metal and semiconductor nanoparticles- effects of reducing reagents and stabilizers; hydrothermal synthesis; sol-gel processing; aerosol synthesis; micellar/microemulsion assisted synthesis; electrochemical synthesis; template-assisted synthesis; sonochemical synthesis, photoreduction method; micro-wave synthesis; biological synthesis ; Spray pyrolysis- VLS and SLS growth, Vapor phase reactions - Chemical vapor deposition-Typical chemical reactions-Reaction kinetics-Transport phenomena- CVD methods, Atomic Layer Deposition (12)

PHYSICAL APPROACHES: Physical Vapor Deposition processes - Evaporation-transport-reaction-deposition; Electron-beam physical vapor deposition, Molecular beam epitaxy (MBE); DC magnetron and RF Sputtering, Thermal evaporation, Pulsed Laser Deposition , Ball milling process (11)

FUNCTIONAL NANOINTERFACES: Self assembly – classification of self assembly process, Self Assembled Monolayer, Monolayers of organosilicon, alkanethiols and sulfides, Langmuir Blodgett (LB) films – micelle formation– Biomimetic approach-superhydrophobic surfaces, Electrochemical Deposition, Electroless/Electroplating, Electrophoretic deposition, Electrospinning. (11)

Total L: 45

REFERENCES:

1. Cao G, “Nanostructures and Nanomaterials: Synthesis, Properties and Applications”, World Scientific Publishing, Singapore, 2011.
2. Yasir Beeran Pottathara,et.al., “Nanomaterials Synthesis,Design, Fabrication and Applications”, Elseiver, USA, 2019
3. Rao C N R, Muller A and Cheetham A K, “The Chemistry of Nanomaterials Synthesis, Properties and Applications”, Wiley-VCH, Germany, 2006.
4. Pradeep T, “Nano: The essentials, Understanding Nanoscience and Nanotechnology”, Tata McGraw Hill, New Delhi, 2007.
5. A. K. Haghi, Ajesh K. Zachariah, Nandakumar Kalarikkal, Nanomaterials Synthesis, Characterization, and Applications, Advances in Nanoscience & Technology, Vol 3, Apple academic press, New Jersey, 2013

21LN04 MATERIALS SCIENCE

3 1 0 4

STRUCTURE OF CRYSTALLINE SOLIDS: Atomic bonding – crystalline state of solids-Crystal structure – Unit cell – Bravais Lattice-Crystal systems-Lattice parameters-Crystallographic planes and directions- Miller Indices- reciprocal lattice- - structure& shape factor-Diffraction by simple space lattice-Crystal imperfections. (11)

ELECTRICAL PROPERTIES: Free electron theory – Fermi Dirac distribution- Density of States- Sommerfeld’s theory of electrical conductivity-work function- Kronig-Penny model – Brillouin zones- Band model for metals, semiconductors and insulators. Dielectric properties: static dielectric constant – Complex dielectric constant- Dielectric losses and relaxation time-ferroelectrics and piezoelectrics: Classification and properties of ferroelectrics, piezoelectric materials and applications. (11)

SEMICONDUCTING AND MAGNETIC PROPERTIES: Electronic degeneracy in semiconductors- Carrier concentration in intrinsic and extrinsic semiconductors- Law of Mass action-Fermi level- Hall effect and its applications-Origin of magnetism-Types of magnetic materials- ferromagnetism- Domain theoryMagnetic hysteresis- Weiss molecular field theory- Hard and soft magnetic materials-applications –Anti-ferromagnetism – Ferrites. Superconductors - Meissner effect-Type I and II superconductors-Josephson effect -SQUID. (12)

OPTICAL AND THERMAL PROPERTIES: Optical Phenomena in Insulators Colour of crystals - Excitons - weakly bound and tightly bound excitons. Colour centers – F-centers and other electronic centers in alkali halides Optical Reflectance: Kramer-Kronig relations- luminescence –- Types of luminescence–Einstein’s theory of specific heat- Debye theory- Elastic waves in an infinite 1D array of identical atoms- vibrational modes of a finite 1D lattice of identical atoms, Size effects on optical and thermal properties of materials. (11)

Total 45

TUTORIAL COMPONENTS

- Theory and exercises on indexing of diffraction patterns and identification of crystal structure
- I-V characteristics and dielectric measurements through impedance analysis •
- Characterisation of semiconductors through hall effect
- Optical studies using photoluminescence measurement

REFERENCES:

1. Charles Kittel, “Introduction to Solid State Physics”, Wiley India P. Ltd.,2019.
2. Callister W D, “Materials Science and Engineering”, Wiley Publications,2010.
3. Dekker A J, “Solid State Physics”, Macmillan Publications,2012.
4. Pillai S O, “Solid State Physics, New Age International”, 2017.
5. Michael Shur, “Physics of Semiconductor Devices”, Prentice Hall,1995
6. Physics of Dielectric Materials – B Tareev.
7. V. Raghavan, “Materials Science and Engineering: A First Course", Prentice Hall, 2011

21LN05 NANOELECTRONICS

3 1 0 4

EVOLUTION OF NANOELECTRONICS: Moore’s Law – Silicon Electronics - Limitations – Silicon MOS Transistor from Micro to Nano – Scaling principles, limits to scaling, power constrained scaling limits - Capabilities of nano electronics - physical fundamentals of nano electronics, mean free path, ballistic transport, tunneling effect, energy quantization, electrostatic phenomena and Coulomb blockade. (11+4)

INTEGRATION ISSUES AND DEVICE REQUIREMENTS: Short channel effects - SiO_2 vs High-k gate dielectrics - Integration issues of high-k interface states – Metal Source Drain Junctions – Schottky Barrier-Work function pinning - Transistor fundamentals**,** MOS Electrostatistics, Requirements for Non Classical MOS Transistors. (11+3)

DESIGN OF ELECTRONIC DEVICES: Short Channel MOS Transistor – Split Gate Transistor- Resonant Tunneling Diode (RTD), Three Terminal Resonant Tunneling Devices, Single Electron Transistors, Nano MOSFET, Carbon Nanotube Field Effect Transistors, Nano ferroelectrics - Ferroelectric random access memory - Fe-RAM circuit design. (13+ 4)

SPINTRONICS: Spin orbit interaction - Spin polarization - spin relaxation - spin dependent transport - materials for spin electronics - spin valve and spin tunneling devices, Spin Field Effect Transistor. (10+4)

Total L: 45 + T: 15 = 60

TUTORIAL COMPONENTS:
- Process design and development of 30 nm CMOS inverter.
- Limits of integrated electronics.
- Process and device simulation of CNT FET.
- Spin relaxation in metals and semiconductors.

REFERENCES:

1. George W. Hanson, Fundamentals of Nanoelectronics, Pearson Education India, New Delhi, 2009.
2. Rainer Waser, Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, Wiley Vch Verlag,Weiheim, 2012.
3. Shunri Oda, David Ferry, Silicon Nanoelectronics, CRC Press, Boca Raton, 2006.
4. Karl Goser, Peter Glosekotter, Jan Dienstuhl, Nanoelectronics and Nanosystems : From Transistors to Molecular Quantum Devices, Springer, New York, 2004.

21LN72 AUDIT COURSE I

vide Automotive Engineering 21AE72

21LN51 SYNTHESIS OF NANOMATERIALS LABORATORY

0 0 4 2

PREAMBLE:
- Preparation of nanofibers using Electrospinning method and to characterize it using AFM
- Preparation of metal nanoparticles using chemical reduction method and characterize it using UV-Vis spectroscopy
- Preparation of Metal oxide nanomaterials
- Fabrication of nanofilms-chemical method
- Demonstration of Ball Milling process

Total P: 60

21LN52 NANOFABRICATION LABORATORY

0 0 4 2

PREAMBLE:
- Fabrication and characterization of thin film organic solar cells and transistors.
- Design and fabrication of 3D printed components.
- Fabrication and characterization of nanocomposite sensors.
- Simulation of electronic devices and fabrication.

Total P: 60

SEMESTER II

21LN07 CHARACTERIZATION OF NANOMATERIALS

3 0 0 3

COMPOSITION AND MICROSTRUCTURAL ANALYSIS: Infra red spectrometry - Raman spectroscopy, Nuclear Magnetic Resonance Spectroscopy, Secondary ion mass spectroscopy, Auger emission spectra, X-ray photoelectron spectroscopy, Atomic Absorption Spectroscopy , Energy Dispersive spectroscopy, X-ray diffraction, Selected area electron diffraction. (12)

MICROSCOPIC ANALYSIS: Optical microscopy, scanning electron microscopy, transmission electron microscopy, atomic force microscopy, scanning tunnelling microscopy, Dynamic light scattering, Confocal microscopy (11)

OPTICAL ANALYSIS: Interaction of electromagnetic radiation with materials, UV-Visible Spectroscopy - Fluorescence spectroscopy, flame emission spectroscopy, X-ray fluorescence. (11)

THERMAL ANALYSIS AND MECHANICAL ANALYSIS: Differential scanning calorimetry –thermogravimetric analysis-differential thermal analysis-thermomechanical analysis, dynamic mechanical analysis - micro hardness - nanoindendation, Friction force microscopy. (11)

Total L: 45

REFERENCES:

1. Ratna Tantra, “Nanomaterial Characterization An Introduction”, Wiley, 2016
2. Alexander Shard, et.al, “Characterization of Nanoparticles Measurement Processes for Nanoparticles”, Elseiver, USA, 2019
3. Ajesh K Zachariah et.al., “Spectroscopic Methods for Nanomaterials Characterization” Elseiver, Micro and nanotechnology series, Vol.2, USA, 2017
4. Willard, “Instrumental Methods of Analysis”, Van Nostrand, 2000

21LN08 MEMS AND NANOFABRICATION

3 0 0 3

INTRODUCTION AND MATERIALS FOR MEMS: MEMS and microsystems - microsystems and microelectronics - MEMS challenges – clean room technologies-scaling - substrates and wafer- silicon substrate - silicon compounds - silicon dioxide, silicon carbide, silicon nitride, polycrystalline silicon- gallium arsenide - quartz- piezoelectric crystals -polymers - polymers for MEMS, conductive polymers. (12)

MEMS TECHNOLOGIES AND PACKAGING: Bulk micromachining - Isotropic and anisotropic etching, wet etchants, etch stop, dry etching, comparison of wet and dry etching - surface micromachining - Introduction, process, associated problems - LIGA Process and electroplating - Integration of electronics and MEMS technology- packaging - post fabrication process, package selection, die attach, Wire bond and Sealing. (12)

NANOFABRICATION PROCESS: Overview of Physical Vapour Deposition (PVD),Chemical Vapour Deposition (CVD). Ion implantation - optical lithography -optical projection lithography, photo mask – fabrication – inspection - defects - repair-resists - Phase shift mask lithography, off-axis illumination, optical proximity correction, immersion lithography. (12)

MODERN LITHOGRAPHIC TECHNIQUES: Electron beam lithography - scattering with angular limitation projection e-beam lithography (SCALPEL) -projection reduction exposure with variable axis immersion lenses (PREVAIL), ion beam lithography, extreme ultraviolet lithography, dip pen lithography, soft lithography. (9)

Total L: 45

REFERENCES:

1. Tai Ran Hsu, MEMS and Microsystems, Design, Manufacture, McGraw Hill Education, Noida, 2017.
2. Marc J Madou, Fundamentals of Microfabrication and Nanotechnology, CRC press, Boca Raton, 2011.
3. Harry J Levinson, Principles of Lithography, SPIE, Bellingham,2019.
4. James J Allen, Micro Electro Mechanical System Design, Taylor & Francis, Boca Raton, 2005.
5. Sami Franssila, Introduction to Microfabrication, John Wiley & Sons Ltd, United Kingdom, 2010.

21LN82 AUDIT COURSE II

vide Automotive Engineering 21AE82

21LN61 MICRO AND NANO DEVICE DESIGN LABORATORY

0 0 4 2

PREAMBLE:

- Study of simulation tools and device design optimization techniques
- Design and analysis of
  - Micro needles and micro fluidic channels for biomedical applications
  - MEMS microphone and micromirror for electronic applications
  - Gyroscope and accelerometer for industrial applications
  - Electrochemical biosensor and scaffolds for diagnostic and therapeutic applications

Total P: 60

21LN62 CHARACTERIZATION OF NANOMATERIALS LABORATORY

0 0 4 2

PREAMBLE:

Characterization of the nanoparticles/materials using the following techniques and interpretation of the data

- Fourier Transform Infrared spectroscopy
- Transmission Electron Microscopy analysis
- XRD pattern analysis
- Particles size analysis data

- Interpretation of UV-Vis Spectra
- Differential scanning calorimetry.

Total P: 60

21LN63 INDUSTRIAL VISIT AND TECHNICAL SEMINAR

vide Automotive Engineering 21AE63

SEMESTER – III

21LN71 PROJECT WORK – I

vide Automotive Engineering 21AE71

SEMESTER – IV

21LN81 PROJECT WORK – II

Vide Automotive Engineering 21AE81

PROFESSIONAL ELECTIVE THEORY COURSES (Four to be opted)

21LN21 NANOSTRUCTURES IN MEDICINE

3 0 0 3

NANOMEDICINE: Development of nano medicines - Nano Shells - Nano pores - Tectodendrimers - Nanoparticle drug system for oral administration - Drug system for nasal administration -Drug system for ocular administration -Nanotechnology in diagnostic application, cellular interactions with nanomaterials. (11)

SMART ASSEMBLIES: Nano and microparticulate delivery systems-the homing device challenge, nanoparticles in biomedical screening and molecular imaging-analyte detection and screening-gold oligonucleotide nanoprobes-fluorescent silica nanoprobes, molecular imaging, targeted radionuclide imaging. (11)

TARGETED DRUG DELIVERY: Opsonization of polymer surface-blood compatibility of polymer surfaces-nanospecific blood-nanoparticle interaction-complement activation and cell opsonization-leukocyte activation, suppression of opsonization and nonspecific cell-particle interaction, clinical evaluation of long circulating nanocapsules, (11)

NANOSTRUCTURED MICROCAPSULES AND NANOGELS: Microcapsules with nanochanneled thermoresponsive layers, microcapsules with sandwiched thermoresponsive membranes, nanogel-matrix membranes, thermocontrolled protein delivery devices. Preparation of nanogels-microemulsion polymerization-chemical crosslinking-physiochemical crosslinking, stimuli responsive nanogels, nanogel applications in drug delivery. (12)

Total L: 45

REFERENCES:

1. Alf Lamprecht, “Nanotherapeutics Drug Delivery Concepts in Nanosience”, Pan Stanford Publishing, Singapore, 2014.
2. Mingjun Zhang and Ning Xi, “Nanomedicine: A Systems Engineering Approach”, Pan Stanford Publishing, Singapore, 2012.
3. Kewal K Jain, “The Handbook of Nanomedicine”, Humana Press, New Delhi, 2008.
4. Reza Arshady and Kenji Kono, “Smart Nanoparticles in Nanomedicine”, MML series volume 8, Knetus Books, London, 2006.
5.Sourav Bhattacharjee, “Principles of Nanomedicine”, Jenny Stanford Publishing Pte.Ltd, 2020

21LN22 NANOTHERAPEUTICS

3 0 0 3

Introduction to nanotherapeutics- Nanocarrier for drug delivery- design, manufacturing and properties- Types of nanocarriers- factors affecting carrier properties- storage and stability (11)

Transport of nanocarriers in Biological systems- transport of polymeric nanoparticles, polyelectrolyte complex, lipids based nanocarriers- liposome, SLN, lipoplexes, dendrimers, carbon and metal nanoparticles. (11)

Nanotargeting approaches- Coupling of targeting moieties- types of coupling methods- post insertion method- avidin biotin complex, coupling of moieties before and after nanocarrier formulation. (11)

Disease related approach by nanotherapeutics- Cancer therapeutics- Hepatic, renal- ovarian- breast cancer, hematologic malignancies, Nanotherapeutics for skin disease-challenges in transport- nanocarriers for skin treatment- Nanotherapeutics for bacterial diseases- antibiotics and nanoenclapsulation- therapeutic application. Advantages and limitations (12)

Total L: 45

REFERENCES:

1. Mingjun Zhang and Ning Xi, “Nanomedicine: A Systems Engineering Approach”, Pan Stanford Publishing, Singapore, 2013.

2. Alf Lamprecht, “Nanotherapeutics Drug Delivery Concepts in Nanosience”, Pan Stanford Publishing, Singapore, 2009.
3. Kewal K Jain, “The Handbook of Nanomedicine”, Humana Press, New Delhi, 2012.
4. Reza Arshady and Kenji Kono, “Smart Nanoparticles in Nanomedicine”, MML series volume 8, Knetus Books, London, 2006.
5. Robert A and Freitas Jr, “Nanomedicine Volume IIA: Biocompatibility”, S Karger Ag, Switzerland, 2003.

21LN23 REGENERATIVE MEDICINE

3 0 0 3

MOLECULES THAT ORGANIZE CELLS: Changes in cell-cell adhesion- Changes in cell-ECM adhesion- Changes in cell polarity and stimulation of cell motility- Invasion of the basal lamina. (11)

CELL-ECM INTERACTIONS IN REPAIR AND REGENERATION: Composition and Diversity of the ECM- Receptors for Extracellular Matrix Molecules, Signal Transduction Events during Cell- ECM Interactions, Cell-ECM Interactions during Healing of Skin Wounds, Cell- ECM Interactions During Regeneration. (11)

NANOTECHNOLOGY FOR REGENERATIVE MEDICINE:Properties of nanomaterials, strategies in regenerative medicine-bone-muscle-vascular-other tissues-stem cells, biological scaffolds composed of ECM, hydrogel in regenerative medicine, scaffolds, 3D-tissue and organ printing- bioink. (11)
CELL AND TISSUE REGENERATION: Bone & cartilage regeneration, cell therapy for blood substitutes- regeneration of cardiac and renal tissues, regenerative medicine manufacturing-challenges and opportunities- Regulations and ethics. (12)

Total L: 45

REFERENCES:
1. Fisher J P, Mikos A G and Bronzino J D, “Tissue Engineering”, CRC Press, Boca Raton, 2012.
2. Robert Neeram, Thomson ,Lanza and Atala, “Principles of regenerative medicine”, Elseiver, Canada, 2011.
3. Sujata V Bhat, “Biomaterials”, Narosa Publication House, New Delhi, 2012.
4. Cato T Laurencin and Lakshmi S Nair, “Nanotechnology and Tissue Engineering: The Scaffold”, CRC Press, Boca Raton. 2008
5. Lanza R, Langer R and Vacanti J, “Principles of Tissue Engineering”, Elsevier Intl, Amsterdam, 2007.

21LN24 PHOTOVOLTAIC TECHNOLOGY

3 0 0 3

SEMICONDUCTOR PROPERTIES FOR PV: First, second and third generation photovoltaics - Optical absorption and carrier photo generation- Direct vs. indirect bandgaps- Heavy doping effects – Moss Burstein and Bandgap Narrowing - Minority carrier transport properties- Carrier recombination-lifetime and defects- Band to band and Shockley-Read-hall - High injection effects- Surface and interface recombination - PN homojunctions and carrier transport under broad spectrum illumination- Photocurrent and spectral response- Current transport models. (12)

SOLAR CELL DESIGN: Solar Cell parameters - Efficiency calculations for ideal cells - Non-idealities: series resistance, shunt resistance - Optical and electrical loss mechanisms - Basics of solar cell device design - Lateral and vertical design - Optical versus electrical tradeoffs and optimization. (11)

SILICON AND THIN FILM PHOTOVOLTAIC CELLS: Si photovoltaics - High efficiency single crystal Si PV designs- Polycrystalline/microcrystalline Si solar cells- Amorphous Si-Heterojunctions – Thin film II-VI photovoltaics - Polycrystalline heterojunctions - CdTe/CdS and CuInGaSe2 /CdS thin film cell technologies III-V Heterojunction and Heterinterface Cells. (11)

HIGH EFFICIENCY PHOTOVOLTAICS: III-V multi-junction solar cells- Spectral splitting and the GaInP/GaAs/Ge triple junction solar cell - Bandgap profile optimization and solar spectrum matching - Tunnel junctions and current matching limitations - Concentrator Photovoltaics - Space photovoltaics- Radiation effects in semiconductors and solar cells - Organic (Polymer) photovoltaics - Dye sensitized solar cells-GaAs - New concepts – quantum dots, wires, intermediate band, multiple exciton. (11)

Total L: 45

REFERENCES:
1. Stephen J Fonash, Solar Cell Device Physics, Academic Press, Cambridge, 2010.
2. Martin A Green, Third Generation Photovoltaics: Advanced Solar Energy Conversion, Springer, New York, 2005.
3. Tomas Markvart. Solar Electricity, John Wiley & Sons Ltd, England, 2000.
4. Hans Joachim Moller, Semiconductors for Solar Cells, Artech House Inc, Norwood, 1993.
5. Adolf Goetzberger, Joachim Knobloch, Bernhard Voss, Crystalline Silicon Solar Cells, John Wiley & Sons Ltd, England, 1998.
6. Alan L Fahrenbruch, Richard H Bube, Fundamentals of Solar Cells: Photovoltaic Solar Energy Conversion, Academic Press, New York, 1983.

21LN25 BIOMOLECULAR NANOTECHNOLOGY

3 0 0 3

BIOLOGICAL MOLECULES IN NANODEVICES: Significance of nanobiological devices**,** Design of nanobiological devices, nucleic acids in nanobiological devices-Nucleic Acid Hybridization: Structure and Assembly-Biologically Functional Nucleic Acid Nanodevices, proteins in nanodevices-Polypeptide Affinity Reagents:Targeting, Triggering, and Assembly. (11)

DNA ELECTRONICS: Charge transport mechanism in DNA-indirect measurement of charge transport in DNA-Direct Measurements of Current–Voltage Characteristics-DNA applications in nano scale electronics-DNA Nano scale Wires-DNA Self-Assembly. (11)

DNA-BASED NANODEVICES: DNA technology**-**Force Generation-Branch Migration, A Device Based on the B–Z Transition-Design of the Device-Characterization of the Device—Fluorescence Resonance Energy Transfer, DNA Actuators-DNA Tweezers-DNA Scissors-A Three-State Device, A Device Based on Crossover Junctions-Design and Operation Scheme of the Device - Formation of G-Quartets-Design and Operation of the G-Quartet Device-An Operation Principle for Free-Running DNA Motors. (11)

PROTEIN NANOTECHNOLOGY: S-layer proteins**,** secondary cell wall polymers, s-layer fusion proteins, s-layer monolayer formation on solid surfaces, s-layer templating of nanoparticle arrays, spatial control of the s-layer reassembly, lipid membranes, planar lipid membranes, s-layer ultrafiltration membrane (sum)-supported Lipid membranes, solid-supported Lipid membranes. (12)

Total L: 45

REFERENCES:

1. Chunhai Fan, “DNA nanotechnology from structure to function”, Springer, London, 2013.
2. Yoseph Bar Cohen, “Biomimetics: Biologically Inspired Technologies”, CRC Press, Boca Raton, 2006.
3. Itamar Willner, Eugenii Katz, “Bioelectronics: From Theory to Applications,” Wiley-VCH,Germany, 2005
4. David S Goodsell, “Bionanotechnology: Concepts, Lessons from Nature”, Wiley-Liss, New Jersey, 2004.
5. Niemeyer C M and Mirkin C A, “Nanobiotechnology, Concepts, Applications and Perspectives”, Wiley-Vch, Germany, 2004.

21LN26 POLYMER NANOCOMPOSITES

3 0 0 3

PREPARATION OF POLYMER NANOCOMPOSITES: Definition of nanocomposite, polymer matrix, nanofillers, classification of nanofillers, carbon and non-carbon based nanofillers- synthesis and properties of fillers, Nanofibers, Electrospinning, Composites manufacturing, Synthesis of Nanocomposites: Dispersion, Direct Mixing, Solution Mixing, In-Situ Polymerization, In-Situ Particle Processing, Nanocomposite fiber, Nanocomposite coating, Modification of Interfaces, Modification of Nanotubes, Modification of Nanoparticles (12)

CHARACTERIZATION OF POLYMER NANOCOMPOSITES: Characterization techniques for polymer nanocomposites , Mechanical Properties, Modulus, Failure Stress and Strain, Toughness, Thermo-mechanical behavior, Abrasion and Wear Resistance, Permeability, Dimensional Stability Contents, Thermal Stability and Flammability, Conductivity, Percolation threshold, Resistivity, Permittivity and Breakdown Strength (11)

PROPERTIES OF POLYMER NANOCOMPOSITES: Properties of various polymer nanocomposites: Carbon nanofiller/Polymer Composites, Metal/ceramic nanoparticle based composites, Layered Filler/Polymer Composites, Biodegradable polymer nanocomposites, Barrier properties, Electrical and Optical Properties, Permeation and diffusion models (10)

ADVANCED POLYMER NANOCOMPOSITES: Multi-scale nanocomposites, Nanocomposite nanofibers, Hybrid nanoparticles, Nanoencapsulation, Wear resistant polymer nanocomposites, Surface treatments, Application of Polymer Nanocomposites – Automobiles, Aerospace, Injection Molded Products, Coatings, Adhesives, Fire-retardants, Packaging Materials, Microelectronic Packaging, Integrated Circuits, Drug Delivery, Sensors, Membranes, Medical Devices, Implants, Consumer Goods, Nanoemulsion. (12)

Total L: 45

REFERENCES:

1. Yiu-Wing Mai and Zhong-Zhen Yu, Polymer nanocomposites, Woodhead Publishing Limited, England, 2006,
2. Rakesh K Gupta, Elliot Kennel and Kwang Jea Kim, Polymer nanocomposites Handbook, CRC Press, Boca Raton,2009.
3. Joseph H Koo, Polymer Nanocomposites: Processing and applications, McGraw Hill, New York, 2019.

21LN27 NANOPHOTONICS

3 0 0 3

LINEAR AND NONLINEAR PHOTONICS: Optical luminescence and fluorescence from direct bandgap semiconductor nanoparticles, light emission from indirect semiconductors, Maxwell’s Equations, Photonic Band Gap and Localized Defect States, Transmission Spectra, Nonlinear Optics in Linear Photonic Crystals, Guided Modes in Photonic Crystals Nonlinear Photonic Crystal Analysis. (11)

PLASMONICS: Plasmonics, merging photonics and electronics at nanoscale dimensions, single photon transistor using surface plasmon, nanowire surface plasmons-interaction with matter, single emitter as saturable mirror, photon correlation, and integrated systems – Optical modulation by plasmonic excitation of quantum dots, Near-field photonics: surface plasmon polaritons and localized surface plasmons, slow guided surface plasmons at telecom frequencies. (12)

NANOSTRUCTURE PHOTONICS: Surface Structures - Random Surfaces - Controlled Random Surfaces - Black Silicon, Thin Film Structures and Optical Coatings, Photonic Crystals, Optical Properties of Materials Including Quantum Structures - Frequency Conversion - Charge Carrier Generation - Multiple Exciton Generation - Graphene photonics and optoelectronics. (12)

BIOPHOTONICS: Interaction of Light with cells and tissues - Nature of optical interactions (optical loss and optical transparency) - Optical properties of a tissue (Double integrating sphere experiment) – Light-induced processes in tissues – Auto fluorescence, photochemical processes, thermal effects, photo ablation, plasma induced ablation and photo disruption (10)

Total L: 45

REFERENCES:

1. Mool C Gupta, John Ballato, The Handbook of Photonics, CRC Press, Baca Raton ,2006.
2. Valery V Tuchin, Handbook of Photonics for Biomedical Science, CRC Press, Baca Raton ,2010.
3. Ralf Menzel, Photonics: Linear and Nonlinear Interactions of Laser Light and Matter, Springer Verlag, New York,2007.
4. V M Shalaev, S. Kawata, Nanophotonics with Surface Plasmons, Elsevier Science, Boston, 2006.
5. Paras N Prasad, Introduction to Biophotonics, John Wiley and Sons, New Jersey,2003

21LN28 BIOMATERIALS AND TISSUE ENGINEERING

3 0 0 3

BIOMATERIALS: Biocompatibility- introduction to biological fluids- material response: swelling and leaching, corrosion and dissolution, deformation and failure, friction and wear - host response: the inflammatory process - coagulation and hemolysis- approaches to thrombo- resistant materials development.Cells: theirs surface and interaction with materials. (11)

CLASSES OF MATERIALS: Metals-gold- silver- copper, metal oxides-iron oxide-titanium oxide- zinc oxide, polymers-PLGA-PVA-PEG- Poly cyclodextran, ceramics, composites, natural materials, biologically functional materials (11)

TISSUE ENGINEERING: Cell - extracellular matrix - cell as therapeutic agent - cell number and growth rate - cell differentiation - cell migration - cell death - types of tissues - tissue dynamics - homeostasis in highly prolific tissue - tissue repair – nanomaterials for cell engineering - nano structured extra cellular matrix - electrospun nanofibrous polymeric scaffold ,bioreactors for tissue engineering. (11)

TISSUE ENGINEERING APPLICATIONS: Skin transplant, Bone and cartilage tissue engineering, nervous tissues engineering-tissues engineering of organs and systems ethical issue in tissue engineering. (12)

Total L: 45

REFERENCES:

1. Clemens van Blitterswijk Jan De Boer, Tissue Engineering, Academic Press, 2015.
2. Temenoff , J S and Mikos , A G ,Biomaterials: The Intersection of Biology and Materials Science, Pearson, 2012.
3. Sujata, V Bhat, Biomaterials, Narosa Publication House, 2009.
4. Lanza, R, Langer, R and Vacanti, J, Principles of Tissue Engineering, Elsevier Intl, 2007.
5. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Biomaterials ScienceAn Introduction to Materials in Medicine, Elsevier Science, 2013

21LN29 POLYMER ELECTRONICS

3 0 0 3

POLYMERIC MATERIALS: Origin, classification, formation of polymers - chain growth and step growth polymerization, copolymerization - Thermoplastics and thermosets - Micro structures in polymers - polymer length, molecular weight, amorphous and crystalline, thermal transitions in plastics. (11)

CONDUCTING POLYMERS: Band theory, insulators, semiconductors, metals, semimetals, poly (sulfur nitride) and polyacetylene - Synthesis, structure and morphology- Conductivity doping, Phenylene polymers - Polypyrrole and Polythiophene - Polyaniline - Stacked phtalocyanine polymers, polymers with transition metals. (11)

FABRICATION OF ORGANIC ELECTRONIC DEVICES: Technology, Materials, Printing and Patterning Techniques, Devices, Printed Electrodes for All-Printed Thin-Film Transistor Applications: Surface Roughness and Edge Waviness in Printed Electrodes - Solution-Processing for Organic TFT , Roll-to-Roll Printing, Gravure Printing, Screen Printing of Cathode, OLEDS, Roll-to-Roll Printed OLED Demonstrators. Flexible Hybrid electronics**.** (12)

SCALING EFFECTS IN ORGANIC TRANSISTORS AND SENSORS: Scaling Behavior- Charge Transport - Characterization - Channel Length and Temperature Dependence of Charge Transport - Field-Dependent Mobility Model - Charge Transport in sub-10-nm Organic Transistors - Chemical and Vapour Sensing with Organic Transistors and their scaling effects. (11)

Total L: 45

REFERENCES:

1. Harry R Allcock, Frederick W Lampe, James E Mark, Contemporary Polymer Chemistry, Pearson Education, London, 2003.
2. Terje A. Skotheim, John R. Reynolds, Conjugated polymers: Theory, Synthesis , properties and characterization (Handbook of Conducting Polymers), CRC Press, Baca Raton,2007.
3. Frances L Gardiner, Eleanor J Carter, Polymer Electronics- A flexible Technology, iSmithers Rapra Technology Pub, Akron, 2009.
4. Ruth Shinar, Joseph Shinar, Organic Electronics in Sensors and Biotechnology, Mc Graw Hill , New York, 2009.
5. Keith Cousins, Polymers in Electronics, iSmithers Rapra Technology Pub, Akron, 2006.

21LN30 NANOBIOMATERIALS

3 0 0 3

NATURAL NANOBIOMATERIALS: Mineral Constituents of the living systems - major elements, minor and trace elements, toxic elements, biomineralization principles, architecture of bone and teeth, nanohydroxyapatite, nanosilica, silk as nanobiomaterial, microstructure of cocoon silk and spider silk, biomimetic nanomaterials - Biologically inspired electro spun nano fibre and nano tubes, Biomimetic formulation of synergistic nanocomposite materials, biomimetic adhesive design and manufacturing. (11)

DIAGNOSTIC NANOBIOMATERIALS: Intrinsic biocompatibility of nanoparticle in cellular system - Nanobiomaterial as contrast agent, photosensitizer, degradable and non-degradable polymers, degradable and resorbable materials, biocompatible polymer coated magnetic nanoparticles for MRI imaging, gold and silver loaded bioconjugated carbon nanotube and graphene for tumor targeting, Silica / CdSe / CdS / ZnO core - shell nanostructures for optical diagnostics and imaging – multifunctional nanobiomaterials for multi imaging modality approaches. (12)

THERAPEUTIC NANOBIOMATERIALS: Nanobiomaterial as therapeutic agent **-** Targeted, non-targeted delivery; controlled drug release; exploiting novel delivery routes using nanoparticles, Cytotoxicity mechanisms and their potential use in therapy, gene therapy using nanobiomaterials; nanostructures for antibiotics; diseased tissue destruction using nanoparticles, Photodynamic therapy, Magnetically induced hyperthermia. (11)

FUNCTIONAL NANOBIOMATERIALS: Goals of nanomaterial use in healthcare, areas of application- nanovectors, nanobio-generators, nanobiosensors, implantable drug delivery devices, status of tissue engineering of specific organs - bone marrow, skeletal muscle, and cartilage, design and engineering of mesoporous scaffold for hard tissue replacement, choice of materials and process techniques, fabrication of hybrid microswimmers, bionanomaterial applications in environmental remediation. (11)

Total L: 45

REFERENCES:

1. Ramakrishna S, Murugan Ramalingam, and Kumar T. S. S., “Biomaterials: A Nano Approach”, CRCPress, London, 2014.
2. Astrid Sigel, Helmut Sigel and Roland K. O. Sigel, “Biomineralization: From Nature to Application”, John Wiley, 2012.
3. Bikramjit Basu and Ashok Kumar K., “Advanced Biomaterials: Processing and Applications”, John Wiley, New Jersey, 2009.
4. Cato T. Laurencin, Temenoff J. S. and Mikos A. G., “Biomaterials: The Intersection of Biology and Materials Science”, Pearson, New Delhi, 2009.
5. Yoseph Bar Cohen, “Biomimetics: Biologically Inspired Technologies”, CRC Press, Boca Raton, 2006.
6. Hari Singh Nalwa, “Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology”, American Scientific Publishers, 2005.

21LN31 NANOTOXICOLOGY

3 0 0 3

TOXICOLOGY AT NANO SCALE: Size-specific behavior of nanomaterials - nanotoxicology challenges - carbon nanotubes in practice - postproduction processing of carbon nanotubes - physicochemical properties of nanomaterials as mediators of toxicity - characterization of administered nanomaterials during toxicity studies - C60 - Graphene issues. (11)

INTERACTION WITH BIOMEMBRANES: Bio-distribution of nanoparticles - localization of particles in tissues - relevance of drug targeting to nanotoxicology Interaction of nanoparticles with lipid bilayers - cell-level studies of nanoparticle - induced membrane permeability - internalization of cation nanoparticles into cells - placental biological barrier model for evaluation of nanoparticle transfer - transport across placental barrier - assessment of placental transfer. (11)

NANOPARTICLE EXPOSURE AND BIOSAFTEY: Physicochemical determinants in particle toxicology - nanoparticles vs. micron-size particles - nanoparticle toxicity comparison to larger counterparts - requirement for appropriate model particles-ASTM-OECD standards -acute immobilization test in daphnia -earthworm acute toxicity test–acute fish toxicity test-exposure assessment, exposure pathways and their significance - documenting the occurrence and nature of exposures, biosaftey(11)

BIOLOGICAL MECHANISM AND ETHICS: Nanoparticles disposition - outline of gene-cellular interactions of nanomaterials - overview of dermal effects of nanomaterials - toxicity of nanoparticles in the eye - scientists as moral agents - the business community and corporations as moral agents - policy makers and regulators as moral agents. ethical and societal implications - the public interface of science technology and human values - origins of the precautionary principle. (11)

Total L: 45

REFERENCES:

1. Nancy A, "Monteiro Riviere Lang Tran", Nanotoxicology, CRC Press, 2014.
2. Deb Bennett Woods, "Nanotechnology: Ethics and Society", CRC Press, Taylor and Francis Group, 2008.
3. Lynn Goldman and Christine Coussens, "Implications of Nanotechnology for environmental Health Research, National Academic Press, Washington,2007.
4. Patrick Lin, Fritz Allhoff, "Nano-ethics: The Ethical and Social Implications of Nanotechnology", John Wiley and Sons, Hoboken NJ 2007

21LN32 NANOTECHNOLOGY FOR ENERGY SYSTEMS

3 0 0 3

SOLAR PHOTOVOLTAICS : Energy challenges and crisis -Solar radiation, evolution of solar cells, amorphous and crystalline silicon, Thin films, Cadmium telluride solar cell, Copper indium gallium selenide solar cell, Gallium arsenide multi-junction solar cell, Dye-sensitized solar cell, Quantum Dot Solar Cells (QDSCs), Organic/polymer solar cells, hybrid photovoltaic system. (13)

MICRO BATTERIES: Super ionic solids - Nano-ionic materials - thin film battery- electrolyte thin films- capacity of a cell - power and energy density of a cell - polymer electrolytes – micro super capacitors- electrolytic-double-layer, electrostatic-pseudocapacitors. Primary lithium batteries - Secondary lithium batteries - Li-ion electrode materials - Applications of Lithium batteries in electronic devices and industries- Graphene as Energy Storage material. (10)

FUEL CELL TECHNOLOGY: Types of fuel cells and their characteristics, physical and chemical phenomena in fuel cells, - integration and performance for micro-fuel cell systems - design methodologies - micro-fuel cell power sources, fuel cells for stationary and dynamic applications. (10)

HYDROGEN STORAGE METHODS: Metal hydrides - hydrogen storage capacity - hydrogen reaction kinetics - carbon-free cycle - gravimetric and volumetric storage capacities - hydriding / dehydriding kinetics - thermal management during the hydriding reaction - size effects - distinctive chemical and physical properties - multiple catalytic effects.(12)

Total L: 45

REFERENCES:

1. Kothari D P, Singal K C, Rakesh Ranjan, Renewable Energy Sources and Emerging Technologies, PHI Learning, New Delhi, 2013.
2. Leon Freris, David Infield, Renewable Energy in Power Systems, John Wiley & Sons, London, 2009.
3. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, PHI Learning, New Delhi, 2009.
4. Kiehne H A, Battery Technology Handbook, Marcel Dekkar Inc, New York, 2003.
5. Viswanathan B and Aulice Scibioh M, Fuel Cells: Principles and Applications, Universities Press, Hyderabad, 2009.

21LN33 NANOCOMPUTING

3 0 0 3

DEFECT TOLERANT TECHNIQUES: Digital signals and gates - Silicon nanoelectronics - Nanocomputing in the presence of defects and faults - error detection, masking and reconfiguration - Defect tolerance - approaches for achieving defect tolerance in nanometer domain, tool flow required to achieve defect tolerance, testing, placement and routing - Quadrillion transistor logic systems - cell matrix, overcoming manufacturing defects. (11)

EVALUATION OF RELIABILITY ISSUES: Introduction - Markov Random Field (MRK) design for structural based faults, design for signal based errors- Tools and techniques for evaluating reliability issues for nano architectures - NANOLAB, NANOPRISM, and reliability evaluation of multiplexing based majority systems. (11)

QUANTUM COMPUTING: Nano information processing, prospects and challenges - quantum computation, error correction, computing technologies, fabrication and test challenges, architectural challenges - quantum dot cellular automata – computing, clocking and design rules. (11)

NOVEL COMPUTING TECHNIQUES AND VERIFICATION METHODS: Brief overview of molecular electronics and molecular computing - Use of optics in computing and optical computing paradigms - Role of non linear optics in optical computing - Verification of large scale nanosystems - scalable verification, scalable unbounded and bounded model checking, verification in the presence of unknowns and uncertainties. (12)

Total L: 45

REFERENCES:

1. Vishal Sahni, Debabrata Goswami, Nanocomputing: The Future of Computing, Tata McGraw-Hill, New Delhi, 2008.
2. Sandeep K Shukla and R. Iris Bahar, Nano, Quantum and Molecular Computing: Implications to high level design and verification, Kluwer Academic Publishers, Amsterdam,2004.
3. Karl Goser, Peter Glosekotter, Jan Dienstuhl, Nanoelectronics and Nanosystems : From Transistors to Molecular Quantum Devices, Springer, New York, 2004.

21LN34 PRODUCT DESIGN, MANAGEMENT TECHNIQUES AND ENTREPRENEURSHIP

3 0 0 3

ENTREPRENEURIAL COMPETENCE AND ENVIRONMENT: Concept of entrepreneurship - entrepreneurship as a career - personality characteristic a successful entrepreneur - knowledge and skill required for Entrepreneur - Business environment - entrepreneurship development training - centre and state government policies and regulations - international business. (11)

PRODUCT DESIGN AND DEVELOPMENT: Concept generation - product architecture - Industrial design process - criteria for selection of product - product development process - design for manufacture - estimate the manufacturing cost - reduce the support cost - prototyping - economics of product development projects - elements of economic analysis - financial models. (11)

MANAGEMENT OF BUSINESS: Technology management - scientific management - development of management thought - principles of management - functions of management - planning - organization - directing, staffing and controlling - management by objective - SWOT analysis - enterprise resource planning and supply chain management. (11)

PROJECT PLANING AND REPORT PREPARATION: Pre feasibility study - ownership - budgeting - project profile preparation - feasibility report preparation - evaluation criteria - market and channel selection - product launching - monitoring and evaluation of business - effective management of small business- Funding for innovations, startups and small industries – Grants, Debt, Equity – Angel funding and Venture capital funding. (12)

Total L: 45

REFERENCES:

1. Karl T Ulrich and Steven D Eppinger, Product Design and Development, McGraw- Hill, Noida, 2017.
2. Robert D Hisrich, Michael P Peters ,Dean Shepherd ,Sabyasachi Sinha, Entrepreneurship, McGraw Hill, Noida, 2020.
3. Harold Koontz, Cyril O Donnell, Heinz Weihrich,Essentials of Management, McGraw Hill, Noida, 2010.
4. Joseph L Massie, Essentials of Management, Pearson Education, London,1987.

21LN35 NANOSENSORS AND DEVICES

3 0 0 3

SENSOR CHARACTERISTICS: Active and passive sensors - static characteristic - accuracy, error, precision, resolution, sensitivity, selectivity, noise, drift, detection limit - reproducibility, hysteresis, stability, response time, recovery time, dynamic range - dynamic characteristics - zero order, first and second order sensors. (10)

TRANSDUCTION PRINCIPLES: Photoelectric effect - photo dielectric effect - photoluminescence effect - electroluminescence effect - chemiluminescence effect - Doppler effect - Barkhausen effect - Hal effect - Ettinshausen effect - thermoelectric effect - peizoresistive effect – piezoelectric effect - pyroelectric effect -Magneto-mechanical effect (magnetostriction) - Magneto resistive effect. (11)

PHYSICAL SENSORS: Temperature sensor - Pressure sensor – Force sensor – Cantilever sensor - Flow sensor – Accelerometer - Gas sensing with nanostructured thin films - absorption on surfaces, metal oxide modifications by additives, surface modifications - Nano optical sensors- Magnetically engineered spintronic sensors. (12)

CHEMICAL AND BIOLOGICAL SENSORS: Surface interactions - covalent coupling,adsorption,physical entrapment,chemical entrapment - antibodies in sensing - enzymes in sensing - enzyme nanoparticles hybrid sensors - transmembrane sensors. Nanosensor based on Nucleotides and DNA - DNA protein conjugate based sensors- Sensors based on molecules with dendritic architectures. (12)

Total L: 45

REFERENCES:

1. Kourosh Kalantar – Zadeh, Benjamin Fry,Nanotechnology- Enabled Sensors, Springer, New York, 2008.
2. Vinod Kumar Kanna, Nanosensors: Physical, Chemical and Biological, CRC Press, Boca Raton, 2012.
3. Brain R. Eggins, Chemical Sensors and biosensors, John-Wiley & Sons, London, 2002.
4. Kevin C Honeychurch, Nanosensors for Chemical and Biological Applications: Sensing with Nanotubes, Nanowires and Nanoparticles, Woodhead Publishing, Cambridge, 2014.
5. Teik-Cheng Lim, Nanosensors: Theory and Applications in Industry, Healthcare and Defense, CRC Press, Boca Raton, 2011.

21LN37 NANOBIOTECHNOLOGY

3 0 0 3

BASICS OF BIOLOGY: cell, Organelles-Tissues- Nucleic Acids as Genetic-Material. Biomacromolecules - Carbohydrates, Lipids, Proteins and Nucleic Acids, cell-Nanostructure Interactions.transport across membranes- Endocytosis, exocytosis, phagocytosis-pinocytosis-receptor mediated endocytosis. Cell differentiation-proliferation- cell migration- apoptosis. Stem cells, ECM. (11)

PROTEINS AND DNA BASED NANOSTRUCTURE: S-layer as template for arrangement of nanoparticles. Engineered nanopores-supported Bilayers-membrane arrays-Alternative protein pores. DNA-protein Nanostructure-DNA templated electronics-sequence specific molecular lithography- DNA-gold Nanoparticles conjugates- Molecular processor - DNA analyzer as biochip - molecular electronics- DNA as smart glue, DNA computers. (11)

NANOPARTICLES IN THERAPEUTICS: Introduction-polymers –nondegradable synthetic polymers-polyethylene,polypropylene, polytetrafluoroethylene, poly methyacrylates poly hydroxylmethyl acrylates, poly Nisopropyl acrylamide, biodegradable polymers, lipid based colloidal system- factors affecting carrier system-drug load-drug release, stability , dosage. Targeting Approaches**.** (11)

NANOANALYTICS: Quantum dot biolabeling - nanoparticle molecular labels - analysis of biomolecular structure by AFM and molecular pulling - force spectroscopy - biofunctionalized nanoparticles for Surface Enhanced Raman Scattering and Surface Plasmon Resonance. (12)

Total L: 45

REFERENCES:

1. Niemeyer C M and Mirkin C A, “Nanobiotechnology, Concepts, Applications and Perspectives”, Wiley-Vch, Germany, 2004.
2. David S Goodsell, “Bionanotechnology: Concepts, Lessons from Nature”, Wiley-Liss, New Jersey, 2004.
3. Reza Arshady and Kenji Kono, “Smart Nanoparticles in Nanomedicine”, Kentus Books, London, 2006.
4. Greco R S, Prinz and Smith R. L., “Nanoscale Technology in Biological Systems”, CRC Press, London, 2005.
5. Goser K, Glosekotter P and Dienstuhl J, “Nanoelectronic and Nanosystems - From Transistors to Molecular Quantum Devices”, Springer, New Delhi, 2004.

21LN38 QUANTUM MECHANICS

3 0 0 3

ORIGIN OF QUANTUM MECHANICS & FORMALISM: Limitation of classical physics - Planck’s quantum hypothesis - Einstein’s photoelectric effect - wave nature of particle - uncertainty principle - Postulates of quantum mechanics - simultaneous measurability of observable - Linear operator - Hermitian operator - Schrödinger’s time dependent and independent wave equations - particle in a box - harmonic oscillator. (11)

ANGULAR MOMENTUM: particle moving in a spherically symmetric potential - hydrogen atom - hydrogen orbital-angular momentum operators - eigen values and eigen functions of L^2 and L_Z - eigen values of J^2 and J_Z - spin angular momentum - addition of angular momenta - clebsch - gordan coefficients - computations. (11)

TIME INDEPENDENT PERTURBATION THEORY & VARIATION METHOD: Perturbation method – time independent perturbation of non-degenerate and degenerate cases. First and second order correction, applications. Stark effect and Zeeman effect of Hydrogen atom – harmonic oscillator, helium atom. Principles of the variation method for ground state with proof. Application of variation method to He atom, Hydrogen ion molecules and Deuteron. (12)

TIME DEPENDENT PERTURBATION THEORY: First order correction – interaction between electromagnetic waves and atoms – transition probabilities – Einstein’s coefficients – selection rules for harmonic oscillator and hydrogen atom. (11)

Total L: 45

REFERENCES:

1. Aruldhas G, “Quantum Mechanics”, PHI Learning Pvt. Ltd., New Delhi. 2011.
2. Mathews P M and Venkatesan K, “A Text book of Quantum Mechanics”, Tata McGraw Hill, New Delhi, 2007.
3. Dirac P A M, “Principles of Quantum Mechanics”, Oxford University Press, New Delhi, 2006.
4. Edward L Wolf, “Quantum Nanoelectronics”, Wiley Vch Verlag GmbH & Co, Weinheim, 2009.
5. Eisberg R, and Resnick R. “Quantum Physics of Atoms, Molecules, Solids”, Nuclei and Particles, Wiley-India (P) Ltd., 2007.

OPEN ELECTIVES THEORY COURSES

21LC91 / 21LW91 / 21LV91 / 21LN91 SMART CITIES

3 0 0 3

SMART CITIES: Ideal Smart City loop, Socio-economic and environmental issues, Implications of Urbanization, Urbanization models and global trends, Urbanization in India, Criteria for smart cities, Smartness - Citizens, Living, Environment, Mobility, Economy, Governance Pillars of Smart cities, Buildings, Utilities, Smart Energy,Transportation and road Infrastructure, Health Care, Stakeholders' perceptions, Sustainability issues (12)

FUNDAMENTAL TECHNOLOGIES AND OPPORTUNITIES: Ubiquitous computing, Big Data, Networking, Internet of Things, Cloud computing, Service-oriented architectures, Cyber security architectures. Opportunities: Smart street lighting, Smart Parking, Environmental pollution monitoring, Vehicular tracking, Smart Traffic Control, Waste Management, Smart Grid, Amenity availability, Heritage Information portal, Mobile application design, development and Visualization. (12)

ICT FOR SMART CITIES: Complex Urban systems ICT Infrastructure modeling, Typical Edge Environment, Smart Cities as Systems of Systems, IoT Centric approach, IoT Protocols: WiFi, 6LowPAN, Cellular, NFC, LoRa, NBIOT (11)

CASE STUDIES OF SMART CITIES: European Smart cities, Singapore, Taipei and Surabaya, Mumbai and New Delhi. Smart Village Clusters and Urbanization: Application of smart city Concepts (10)

Total L: 45

REFERENCES:

1. Carlo Ratti and Matthew Claudel, “The City of Tomorrow: Sensors, Networks, Hackers, andthe Future of Urban Life (The Future Series)”, Yale University Press 2016.
2. Stephen Goldsmith, Susan Crawford, “The Responsive City: Engaging CommunitiesThrough Data-Smart Governance”, 1st Edition Jossey Bass – Wiley, 2014.
3. Anilkumar ,”Introduction to Smart Cities”,Pearson India Education series Pvt Ltd, 2020.
4. Sameer Sharma ,”Smart cities Unbounded - Ideas and Practices of Smart cities in India”,BloomsburyPublishing India Pvt Ltd, 2018.

21LC92 / 21LW92 / 21LV92 / 21LN92 RADIATION HAZARDS

3 0 0 3

BIOLOGICAL EFECTS OF RADIATION AND PROTECTION: Production and properties - interaction mechanism of RF and mircrowaves with biological systems: Thermal and non-thermal effects on whole body, lens and cardiovascular systems -tissue characterization and Hyperthermia and other applications-Biomagnetism - Effects - applications. (9)

NON IONIZONG RADIATION: Historical context- Extent of the problem-Understanding non-ionising EMR- Units of measurement –The impact of non-ionising EMR on the body- Legislation- Extra Low Frequency Radiation- Definition and use- Health effects- Risk management- Radio Frequency Radiation- Infra Red Radiation- Visible Light-Ultraviolet -Legislation - Implications for practice. (12)

RF AND MICROWAVE RADIATION: Introduction - Sources of radio frequency radiation- Effects of radio frequency radiation- The development of standards for human safety- The calculation of RF field quantities- Microwave antenna calculations and safety with moving microwave beams - Other antenna system calculations -Simultaneous irradiations and peak pulse power limits -Mobile communications systems. (12)

RF RADIATION MEASUREMENTS AND METHODS: Radiation measurements and methods- X-rays and X-ray measuring instruments - Planning surveys and measurements - Conducting radiation measurements and surveys Leakage surveys - Exposure measurements -Designing to reduce radiation hazards - Radio frequency radiation safety management and training. (12)

Total L : 45

REFERENCES :

1. Ronald Kitchen,”RF Microwave Radiation Safety Handbook”, Newness, Second Edition, 2001.
2. Thomas S. Curry, James E. Dowdey and Robert E. Murry, “Christensen's Physics of Diagnostic Radiology”, Lea & Febiger,U.S.Fourth Edition, Reprint 2010.
3. Harry Moseley, Hospital Physicists' Association, Non-ionising radiation: microwaves, ultraviolet, and laser radiation, A. Hilger, in collaboration with the Hospital Physicists' Association, 1988.